Effect Of Small-Scale Ocean Fluctuations On Ocean Acoustic Transmission

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LONG-TERM GOAL

To connect the results of sound transmission and scattering experiments to known or hypothesized structures within the ocean, such as internal waves or microstructure, with account taken of anisotropy, inhomogeneity, and the sound channel.

OBJECTIVES

To use observations from experiments to determine intemal-wave strength as a function of geographical position and time.

APPROACH

We have simulated realizations of oceans filed with internal waves, and have calculated acoustic fluctuations by use of the paraxial approximations, and two calculational techniques: geometrical optics (integration along unperturbed rays), and multifrequency parabolic-equation solving. We have also studied the effect on acoustics of the temperature-salinity structure of the world ocean.

RESULTS

We have used the World Ocean Atlas 94 database to evaluate world water masses for the strength of intemal-wave effects on acoustics. We have found that different regions have significantly different intemal-wave effects, due to their unique temperature-salinity characteristics. This work has been submitted for publication to J.A.S.A. (Work with Kimberly Noble for her Master's Thesis)

The following figures present a factor F that provides the strength of acoustic travel-time fluctuations, given that a reference strength of internal waves is present. This factor depends on the T-S behavior of the ocean water through which the sound travels, and so is best associated with particular oceanographic water masses listed in each figure.

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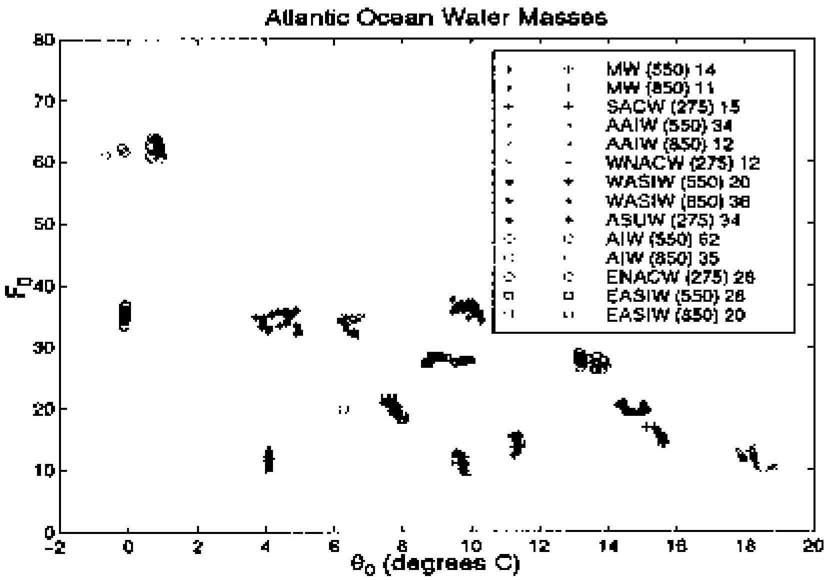
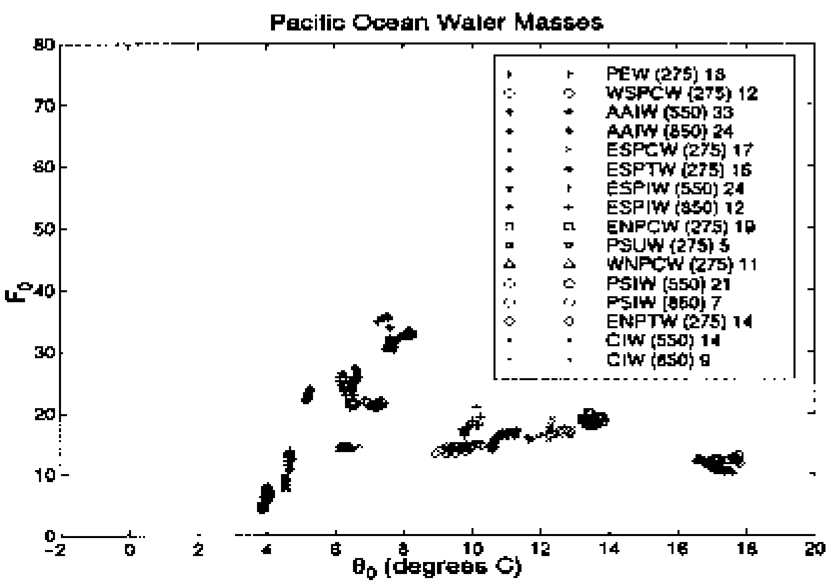
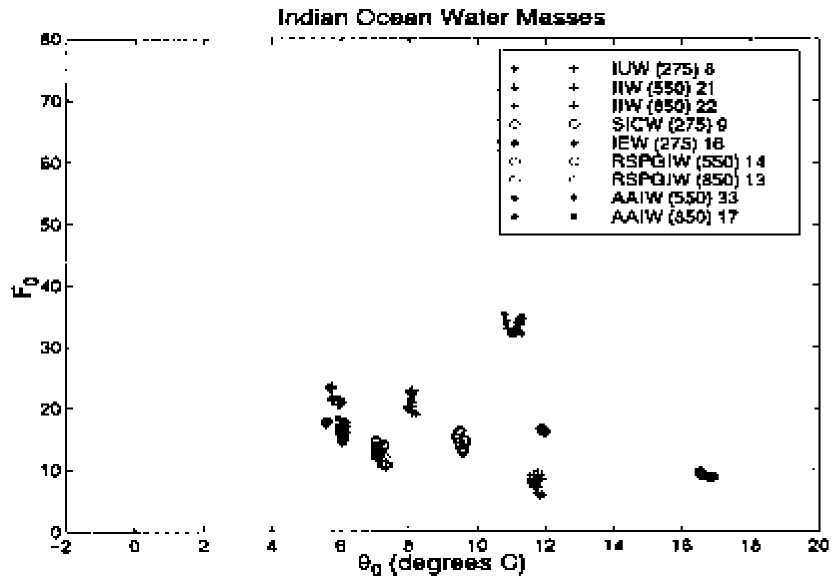


Atlantic Ocean Water Masses
MW (550) 14
MW (850) 11
SACW (275) 15
AAIW (550) 34
AAIW (850) 12
WNACW (275) 12
WASIW (550) 20
WASIW (850) 36
ASUW (275) 34
AIW (550) 62
AIW (850) 35
ENACW (275) 26
EASIW (550) 26
EASIW (850) 20
F_0
θ_0 (degrees C)



Pacific Ocean Water Masses
PEW (275) 18
WSPCW (275) 12
AAIW (550) 33
AAIW (850) 24
ESPCW (275) 17
ESPTW (275) 16
ESPIW (550) 24
ESPIW (850) 12
ENPCW (275) 19
PSUW (275) 5
WNPCW (275) 11
PSIW (550) 21
PSIW (850) 7
ENPTW (275) 14
CIW (550) 14
CIW (850) 9
F_0
θ_0 (degrees C)



We have analyzed a 270-km, 460-Hz, acoustic transmission experiment that was carried out in the western Atlantic in 1990 by a collaboration between the University of Miami and U.C.S.C. The observations allow the measurement of the movement of caustics at that range. We found that neighboring caustics had relative vertical motions of order ten meters and relative travel-time fluctuations of one millisecond, with correlation times of order half an hour. Other fluctuations are covered in the article submitted for publication to J.A.S.A. (Work with Jeffrey Simmen, GuangYu Wang, Harry Deferrari, Hien Nguyen, and Neil Williams)

We have continued to compare the results from our CAFI program, based on numerical integrals derived by path-integral techniques, with results from PE numerical simulations. We have found it necessary to improve our expressions for the correlation length of internal waves along the ray trajectory. Previous work was based on a straight-line approximation to the ray; we have now improved that to a ray with constant (but non-zero) curvature. The result of this modification is that intemal-wave effects are more isotropic than previously thought, and internal-waveinduced travel-time fluctuationsare usually increased somewhat by this change. These results have been published in the Proceedings of the 1997 Hawaiian Winter Workshop. (with G. Rovner)

We have worked with the ATOC group to evaluate internal-wave strengths for the ATOC transmissions in 1996. Observations of timefront travel-time fluctuations are in the range of I I to 19 ms. Careful calculation with the modified CAFI code shows that these fluctuations imply an intemal-wave strength of 25 MA2 (one-half the Garrett-Munk reference level). This work is in review at J.A. S.A. (with J. Colosi et. al.)

IMPACT/APPLICATION

First, The improvement in CAFI calculations will translate into more accurate predictions of acoustic fluctuations in new environments. New experiments will plan their observations with this improved tool. Second, our systematic survey of intemal-wave-related water-mass characteristics in different geographical locations will translate into better predictions for internalwave-induced fluctuations in U.S. Navy sonar systems. Systematic world-wide verification of these predictions could be a useful U.S. Navy goal.

RELATIONSHIP TO OTHER PROJECTS

We have been involved with the ATOC experiment; we are providing calculation of expected intemal-wave and intemal-tide effects. We expect to be involved in future related experiments such as NPAL. These effects in many cases are the limiting factors on accuracy of travel-time determination. We have found that as the range increases, the effects of internal waves become more easily observable. As a result, in the ATOC experiment there are five different observations that can be used to measure the strength of the internal-wave field. Thus ATOC qualified as an intemal-wave tomography experiment, among its other attributes.

PUBLICATIONS

Kimberly J. Noble and Stanley M. Flatt .. Predicting acoustic fluctuations due to internal waves from the basic climatology of the world ocean, submitted to the J. Acoust. Soc. Am., September, 1998.

Jeffrey A. Simmen, Stanley M. Flatt , Harry A. DeFerrari, and Neil J. Williams. Near-caustic behavior in a 270-km acoustical experiment, submitted to the J. Acoust. Soc. Am., July, 1998.

J.A. Colosi, E.K. Scheer, S.M. Flattd, B.D. Comuelle, M.A. Dzieciuch, W.H. Munk, P.F.Worcester, B.M. Howe, J.A. Mercer, R.C. Spindel, K. Metzger,, T.G. Birdsall, and A.B.Baggeroer. Comparisons of measured and predicted acoustic fluctuations for a 3252-km propagation experiment in the eastern North Pacific Ocean, submitted to the J. Acoust. Soc. Am., October 1997.

S.M. Flatt .. Path-integral expressions for fluctuations in acoustic transmission in the ocean waveguide, In P. Muller, editor, Proceedings of the Ninth 'AhaHuliko'a Hawaiian Winter Workshop, pp. 167-174, School of0cean,Earth, Science and Technology, University of Hawaii, 1997.

Jeffrey A. Simmen, Stanley M. Flatt , and Guang-Yu Wang. Wavefront folding, chaos, and diffraction for sound propagation through ocean internal waves,J.Acoust. Soc. Am., 102:239--255, 1997.